INSTRUCTION MANUAL
FOR
SORENSEN
ISOTRONIC PRODUCTS

AC REGULATORS

500-S

SORENSEN & CO., INC.
375 FAIRFIELD AVE., STAMFORD, CONN.

INSTRUCTION MANUAL

FOR

SORENSEN AC REGULATORS

GENERAL INFORMATION

Before you begin to use your new Sorensen instrument, please read this instruction book very carefully.

The Sorensen Regulator is a precision instrument. This does not mean that your Sorensen instrument will not stand rough handling - it will. How much, will, of course, depend on your own experience and good judgement. You have chosen the Sorensen unit over all other similar types of equipment for any of the reasons listed-

- Wide Input Range
- Precise regulation accuracy
- Excellent wave form
- Insensitivity to line frequency fluctuations
- Adjustable output voltage
- Fast recovery time

The experience and "know-how" which have made Sorensen the first line of STANDARD electronic voltage regulators, stand behind this instrument. If, for any reason, difficulties are encountered, notify the factory at once. . . DO NOT ATTEMPT ADJUSTMENTS OR REPAIRS WITHOUT FIRST NOTIFYING THE FACTORY. DO NOT TAMPER WITH ANY OF THE COMPONENTS. UNINSTRUCTED TAMPERING WITH ANY OF THE COMPONENTS WILL VOID YOUR GUARANTEE FOR THAT PARTICULAR PART.

REQUESTS FOR INFORMATION AND SERVICE

All questions concerning the operation or malfunctioning of this instrument should be directed to the Service Department, Sorensen & Company, 375 Fairfield Avenue, Stamford, Connecticut.

Sorensen & Company, Inc. has adopted a sales and service policy which is meant to be a protection to you as purchaser and Sorensen & Company, Inc. as supplier.

INSPECT INSTRUMENTS AT ONCE FOR SHIPPING DAMAGE

All shipments should be inspected by the buyer upon delivery and in the event of damage in transit, a claim should be filed against the carrier at once.

WARRANTY

Defective instruments or defective components found in the instruments will be considered for adjustment only if Sorensen & Company, Inc. is notified within the Warranty period specified. The period of Warranty (with the exception of the tubes) for this instrument is one year from date of your acceptance.

THE THERMOSEN DIODE IS UNCONDITIONALLY GUARANTEED FOR 2500 HOURS OR ONE YEAR, WHICHEVER EXPIRES FIRST.

The instrument and materials are warranted against defective workmanship and construction, and no other warranty may be implied.

The warranty only covers equipment that is maintained in proper condition and is used by you in skillful and proper manner. No other warranties may be implied.

PROCEDURE FOR RETURNING DAMAGED OR DEFECTIVE MATERIAL

When claiming adjustment for defective materials, the following procedure should be followed:

A. A request should be made directly to the Service Department of Sorensen & Company, Inc. for authorization to return the defective instrument. In order that your

request can be serviced as quickly as possible, it is necessary to list the following information:

1. The order number on which the instrument was shipped.

2. Model number and serial number of the instrument.

3. A brief description of the reason for rejection.

B. It will be determined by the Service Department of Sorensen & Company, Inc. whether a repair will be attempted at your plant by one of our Field Engineers or Representatives. If this is to be done we will notify you immediately and make arrangements for a visit to your plant. If we indicate that the material is to be returned to our Plant for repair or replacement, a RETURN MATERIAL TAG, which outlines a shipping procedure, will be sent to you.

I. SPECIFICATIONS

A. Nominal Ratings

1. Input Voltage Range - 95 to 130 volts AC (or 190 to 260 in "-2S" models).

2. Output Voltage - Rated at 115 V, or 230 in "-2S" models, but adjustable between 110 and 120 volts, or 220 to 240 in "-2S" models.

3. Regulation Accuracy - plus or minus .1% against line or load with a 25°C. ambient.

4. Recovery time -.05 seconds for 150, 250, 500 VA; 0.1 seconds for 1000, 2000 VA; 0.15 seconds for 3000 and 5000; 0.2 seconds for 10,000 and 15,000 VA units. When an abrupt change occurs in the input voltage or in the load an instantaneous change in output Voltage occurs. The magnitude of the instantaneous output-voltage-change is dependent upon the magnitude of the change in load or input voltage. A finite time is necessary for the regulator to restore the output voltage from its maximum deviated value to the normal value. The recovery time is defined as the time necessary to effect at least a 63% complete recovery from its maximum deviated value.

5. Input frequency range - 50 to 60 cycles. Centered at 50 cycles in "C" units, at 60 cycles in standard units.

6. Power Factor Range - 1.0 to .7 power factor lagging. See Graph A, page 7 for complete details.

7. Load Range - 0 to full load. Model number indicates full load rating in VA.

8. Harmonic Distortion - 3% maximum. The rating applies to a nominal input frequency of 60 cycles. See Graph B, page 8. The harmonic distortion rating applies only under conditions of a sinusoidal input voltage, since input distortion can cause appreciable output distortion. Normal distortion 5% in hermetically sealed units.

9. The rated ambient for the unit is -20°C. tc +50°C. although the unit will operate at higher ambients with lighter loads and at lower ambients with some change in operating characteristics.

10. Temperature compensation is employed to reduce the output voltage change that would be present when the ambient is changed over this wide range. The output voltage may shift plus or minus ½ of 1% over this wide ambient range, but the regulation against line or load will be maintained. Most units are fully protected against overload by automatic thermal breakers. Circuitry arrangement and the special diode employed protects the units against over voltage resulting from tube failure.

11. The unit is rated to withstand normal humidity conditions in a sheltered location. The wound components are varnish impregnated in a good commercial manner.

    NOTE: Dangerous voltages exist in the control circuits. Observe appropriate precautions.

12. The controls are located on the front panel. A main power switch is provided for all models except the 5, 10, and 15 KVA units. A fuse for the control circuit only is provided. This fuse does not disconnect the power circuit but merely disconnects the control circuit. A pilot light is also provided to indicate that the control circuit is working. The voltage adjustment control is provided to permit ample voltage adjustment, as rated.

    It must be noted that to completely disconnect all possible voltages from the load or from the internal portions of the unit, the power switch should be off, or the line cord or other connection to the main power opened. Removing a fuse will not completely remove all voltages from the unit or the load. See the schematic for details.

13. The standard finish is grey wrinkle although black wrinkle is also available.

INSTALLATION NOTES

The input power is supplied by using the flexible line cord or terminals.

The output is available at the rear of the unit by inserting a suitable plug into the dual receptacle or using the terminals provided.

The chassis is isolated from the input and output terminals and it is recommended that the chassis and case be grounded. The input is not isolated from the output as is evident by referring to the attached schematic.

The fuse on the front panel is provided as a protection for the control components in the event of an internal failure. The unit is protected against overload by the internal automatic type over-current protector in most models.

Principle of Operation

The operation of the unit can best be understood by referring to the schematic diagrams included.

The basic power circuit includes an autotransformer T4 and a saturable core reactor T3. The reactor is in series with the primary of the autotransformer across the input terminals. Variation of the impedance of the saturable core reactor will vary the voltage impressed on the primary of the autotransformer and consequently will vary the output voltage.

A decrease in reactor impedance, for instance, will increase the portion of the input voltage impressed on the autotransformer primary and will result in an increase in output voltage.

Conversely, an increase in reactor impedance will result in a decrease in output voltage.

All that is necessary to achieve voltage regulation is some automatic method of varying the reactor impedance by the right amount to restore the output voltage to its original value at such times as it may vary due to changes in load or input voltage. This action is accomplished by the electronic control circuit.

The basic voltage sensitive element is the Wheatstone Bridge. One arm of the bridge consists of the diode V1, the filament of which is lighted by the output voltage. In some low capacity models only two arms of the bridge show on the schematic diagram. The power supply has the missing two arms by virtue of its arrangement.

The diode is operated at a temperature limited condition. With this arrangement,

a small increment of output voltage results in a change in cathode emission and a large change of plate resistance in the diode. The signal voltage of the bridge is applied to the grid of beam power tube V2 which controls the DC saturating current of the reactor.

A typical sequence of operations is as follows: Assume a rise in output voltage as a result of reduced load or a rise in input voltage. Increased output voltage results in increased voltage and heating of the diode filament. With increased heating, the diode cathode emission increases reducing the plate resistance of the tube. Since the diode forms an arm of the bridge, a change in plate resistance will change the balance condition of the bridge; in this instance the change results in a more negative potential applied to the grid of V2. The more negative grid signal results in a sharp drop in the plate current of V2 and consequently, reduced saturation of the reactor. Reduced DC saturation of the reactor results in an increase in AC impedance which, as pointed out before, lowers the output voltage.

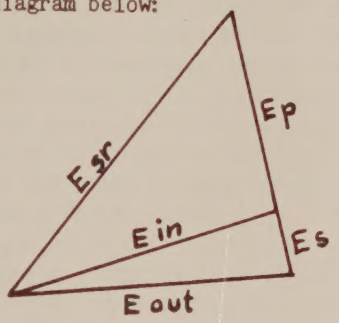
The above action will continue until an equilibrium is reached wherein the net change in output voltage is sufficient to compensate for the changed circuit conditions in the control circuit. The gain of the control system is of such magnitude that the unit will maintain output voltage within tolerance rated, while compensating for the rated range of input voltage and load variations.

The tube V3 is a rectifier tube for the saturating circuit, and S1 a selenium rectifier for the diode bridge circuit. Adjustment of the output voltage is accomplished by the potentiometer in the circuit supplying the diode filament voltage. Variation of the resistance in this circuit varies the value of output voltage required to obtain a given diode filament temperature, and consequently will control the output voltage.

The resistor shown connected between the plate and the screen of tube V2 (across terminals 9 and 10 in high capacity models) is a swamping resistor to absorb inductive surges originating in the DC reactor winding. The winding has a very high inductance.

When the regulator is first turned on, electronic circuit elements are cold and a period of approximately 60 seconds is required for the unit to reach operating temperature. During this period, the output voltage will be low; however, as the tubes begin to conduct, the output voltage rapidly rises to its proper adjusted value. This is a normal condition and in no way indicates any malfunctioning of the regulator.

The phase relationships of the voltages in the power circuit are illustrated by the Vector diagram below:



E_s = voltage of auto trans. sec.

E_p = voltage of auto trans. primary.

E_{sr} = voltage across saturable core reactor.

E in = input voltage

E out = output voltage.

The magnitude of the Vectors are indicative of operation of the regulator at full load and nominal input and nominal output.

II. MAINTENANCE AND TROUBLE SHOOTING

It was stated in the opening paragraphs of this Instruction Booklet that no tampering or adjustments should be attempted if the unit is within the warranty period without first contacting the Service Department, Sorensen & Co., Inc., or your local Sorensen representative. If the unit is outside of the warranty period it should be remembered that damage can be done to various components even when the unit is being checked. It is

most necessary that the user of this equipment be familiar enough with the circuit to avoid such damage. If the simple checks outlined in this section do not point out immediately the source of trouble, the Service Department of Sorensen & Co., Inc., or the local representative of Sorensen, should be contacted immediately.

A. Maintenance

1. During normal life, the unit requires no maintenance or servicing other than the care usually afforded this type of equipment. Vacuum tubes should be replaced at the end of their specified life in accordance with the policies established for the particular application.

2. In the event of malfunctioning of the unit due to deterioration or failure of any of its component parts, a systematic checking procedure will provide the quickest and surest method of locating the difficulty. The following section gives systematic checking procedures which should be followed in locating sources of trouble.

3. The schematic shows the voltages which should exist in various parts of the circuit during normal operation. These voltages should be measured with an electronic type voltmeter.

   NOTE: DANGEROUS VOLTAGES EXIST IN THE CONTROL CIRCUITS. OBSERVE APPROPRIATE PRECAUTIONS.

COMPENSATION PROCEDURE

Definition of compensation: Compensation in Isotronic terms means a reduction of the amount of voltage deviations caused by line or load changes.

The regulator has several components that are factory adjusted to the optimum value and readjustment in the field is not recommended. However, a brief description of the procedure is given to be used in an emergency. As noted on the schematic, R1 is a resistor consisting of a suitable length of nichrome wire. This value is preset at the factory. In general, increasing the value of this resistance will produce an effect of causing the output voltage rise to be less than normal and even decrease when the line voltage is increased. Several trials should produce the optimum value. Although load compensation is primarily determined by the "load line", adjustment of R1 also has some effect on load compensation. Load compensation is obtained by inserting the optimum value of resistance of the conducting lead between the output terminal or point where R1 is connected and the point where the other primary terminal of T2 connects to the output line. This is designated as the "load line" on the schematic. One terminal of the primary of T2 connected to R1. For special conditions under or over compensation can be achieved to cause the same effect for load changes. This latter characteristic is handy when voltage drop in long leads must be accounted for.

Another adjustment involves the resistor designated R8. Adjustment of the resistor may be necessary when a new diode is installed and the voltage adjustment potentiometer does not permit setting the output voltage between 110 and 120V or 220 and 240 in "-2S" models.

Adjustment of R12 is made to secure optimum temperature compensation. This should not be adjusted since the optimum value cannot readily be determined in the field. However, in an emergency the value of this should be such that the output voltage drops 6 to 8 volts when the trial value of R12 is shorted out under full load.

B. Trouble Shooting

1. THE FIRST STEP IN TROUBLE SHOOTING SHOULD BE TO REPLACE TUBES. IN MOST CASES THIS IS ENOUGH TO CURE THE TROUBLE.

2. Problem A - No Output Voltage

   This condition indicates an open in the power circuit.

   Procedure

   a. Check that the On-Off control is in the "ON" position.

   b. Check autotransformer, AC reactor coils, circuit breaker, power leads, and terminals for continuity.

3. Problem B - No Regulation and Low Output Voltage with Load.

   This condition indicates the failure of the electronic control circuit to supply saturating current.

   Procedure

   1. Check the fuse in the control circuit. Replace only with a similar type.

   2. Inspect tube filaments to see that they are lighted.

   3. Check tubes in a tube tester or by replacement with tubes known to be good.

   4. Check the DC power supply. No voltage will indicate a failure of the transformer winding or of the filter condenser. Check rectifier tube.

   5. Check the plate voltage and grid voltage of the beam power tube, V2. If the grid voltage is abnormally negative and causing cut off, check the diode bridge supply voltage and the diode filament supply voltage.

   6. Check the DC reactor winding for an open.

   7. Check the over-voltage circuit breaker if one is used in your unit.

   8. In the case of split-chassis construction, check the inter-chassis terminal boards for secure and correct connections.

   Problem C - No Regulation and High Output Voltage.

   Procedure:

   1. Check to see that the diode filament is lighted.

   2. Check tube V2 in a tube tester or replace with a spare that is known to be good.

   3. Remove V2. If output voltage drops difficulty is in the control circuit.

      Check V2 grid voltage to cathode or ground.

      If this voltage is abnormally positive, or zero, check contacts, connections and resistance values of all components of the bridge. Check diode or replace with a spare known to be good. Check bridge rectifier.

   4. Check the voltage adjusting potentiometer for dirty contacts.

   Problem D - Drift with Age of the Range of Output Voltage.

   This condition indicates a variation of tube characteristics with age.

   Procedure:

   1. Check tubes or replace with spares known to be good.

   Problem E - Reduction of Regulation Range or Poor Regulation in General.

These conditions may be the result of deterioration or failure of various components of the control circuit.

Procedure:

1. Check tubes or replace with spares.

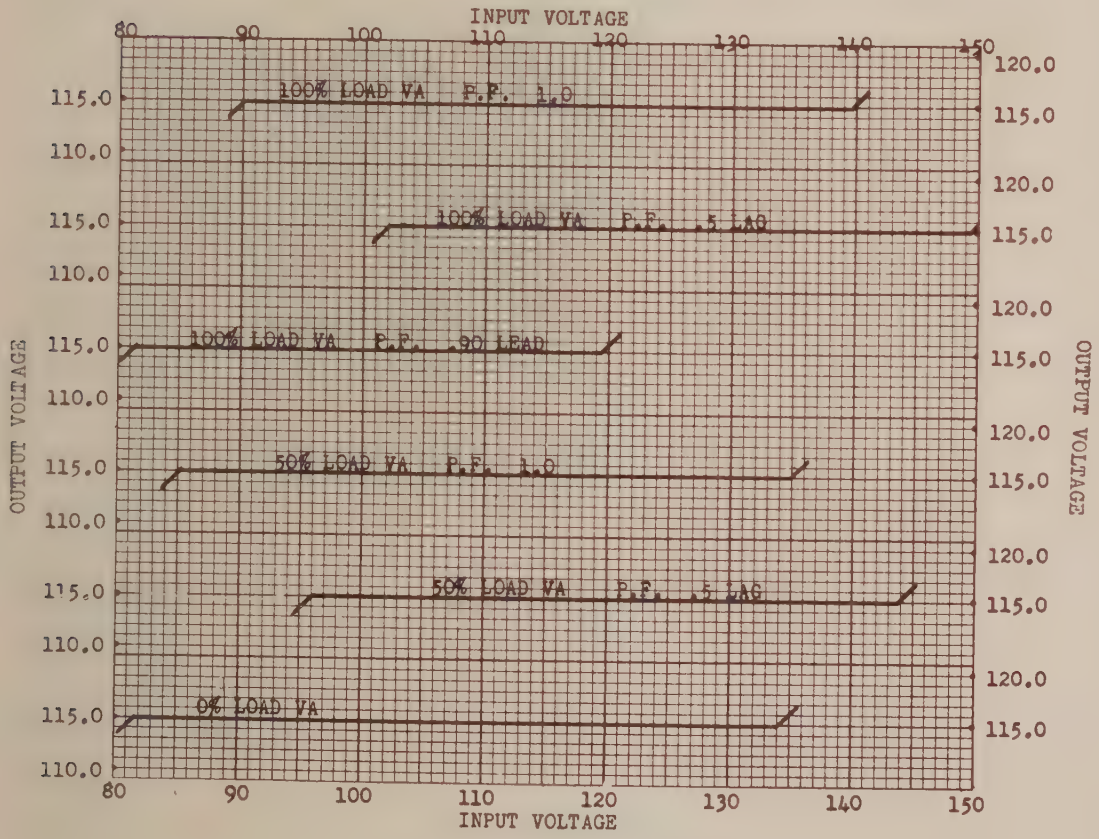
2. Check the DC Power supply voltages.

3. Check the control circuit in general for loose connections, shorts or damaged parts.

4. Check voltage and resistance values. Check condensers by replacement.

5. The output voltage adjustable potentiometer may cause irregular output adjustment. Turn the potentiometer shaft several times in both directions as far as it will go. This is a very low resistance adjustment and contacts can oxidize enough to cause uneven control.

In the event of serious trouble or damage to the unit, return it to the factory for repair and readjustment.

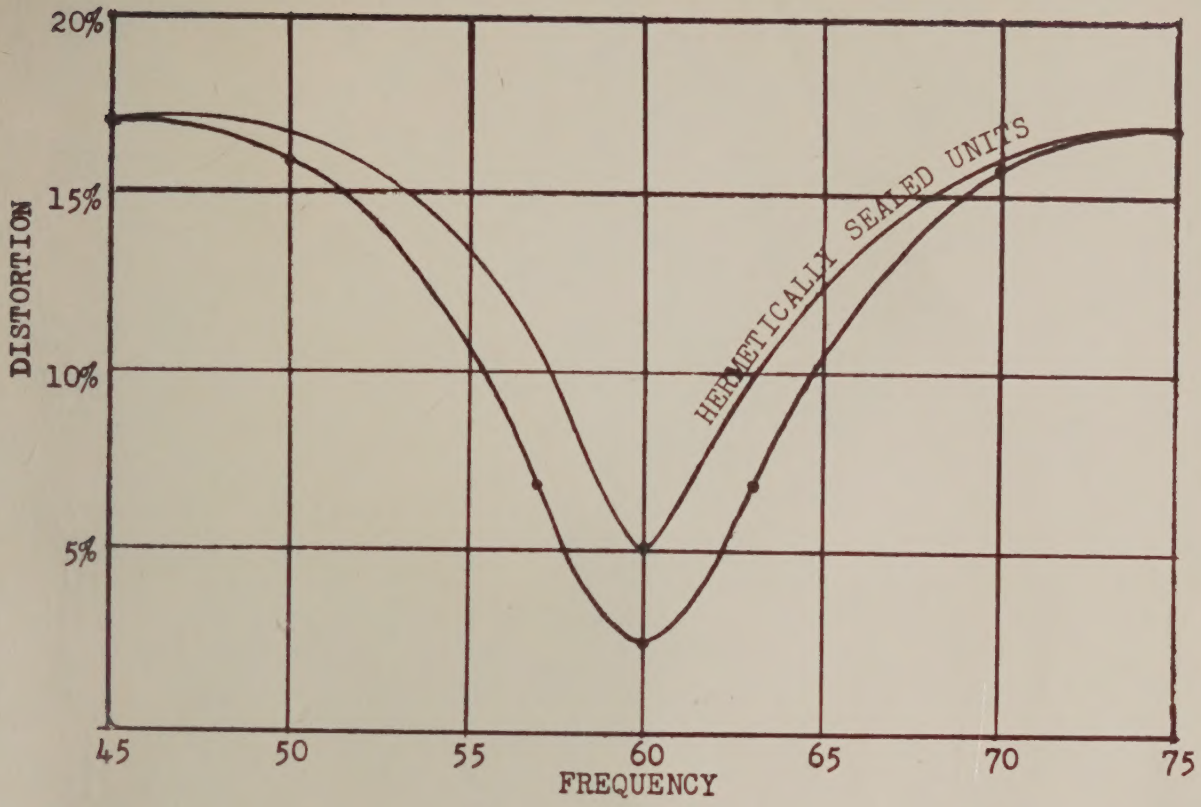


TYPICAL REGULATOR PERFORMANCE

Input Range vs. Load and Power Factor Change

(In "-2S" models double the voltage)

GRAPH A



TYPICAL OUTPUT DISTORTION

VS.

FREQUENCY CHANGES

CENTERED AT 60 CYCLES

GRAPH B

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